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INTEGRATING THE COMPUTER INTO A BUSINESS SCHOOL CURRICULUM

Henry C. LUCAS, Jr.

Jean-Claude LARRECHE

David B. MONTGOMERY

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INTEGRATING THE COMPUTER INTO A BUSINESS SCHOOL CURRICULUM

Henry C. LUCAS, Jr.

Jean-Claude LARRECHE

David B. MONTGOMERY

A Study of Computer Use in a Graduate School of Business

Henry C. Lucas Jr., David B. Montgomery, and Jean Claude Larreche
Stanford University

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Introduction

In the past six years, U.S. business schools have greatly expanded their use of computers in teaching and research. In 1966, only 11 percent of the business schools required student proficiency in programming; by 1970, the total had risen to 62 percent and is undoubtedly higher today [1]. In 1971, the Graduate School of Business (GSB) at Stanford acquired a dedicated time-sharing system to replace the time-sharing services provided by the Stanford Computation Center (SCC). A study of computer usage in the GSB and of the impact of the dedicated time-sharing system was conducted; detailed results may be found in [2]. Our purpose is to present the most interesting and pertinent findings of that study.

A cumulative process model of the development of computing in a business school was developed and used to guide the analysis of data obtained from accounting records and questionnaires administered to students and faculty. The four stages of the model are: (1) the use of a computer by a few faculty members and Ph.D. students for research; (2) the development of a required computer course in the curriculum; (3) the expansion of computer use to other courses through cases, exercises, and projects; and (4) the evolution of the computer system into a general problem solving tool.

Results

The data from GSB support the cumulative process model described above. Before 1968–69, the SCC computer, an IBM 360/67 system, was used primarily for research purposes corresponding to Stage 1 of the model. (The 360 system supports time-sharing and offers a variety of batch processing services.) In 1968, a required MBA course was introduced marking the beginning of Stage 2. Stage 3 was entered in the 1969–70 academic year when a wide variety of courses assigned computer-based exercises. This heavy use was evidenced by a sharp increase in instructional expenditures on the SCC 360 system.

By the fall of 1970, the GSB was confronted with an increase in demands for computer time-sharing services and with an inadequate number of terminals. The SCC time-sharing system required the knowledge of a sophisticated text editor (Wylbur), and system reliability had proved to be a problem. All charges on the 360/67 at the SCC were based on actual usage, creating a budgetary constraint on the expansion of computer use. A decision was made to acquire an HP 2000C dedicated time-sharing system which would be available as a free good to GSB students, faculty, and staff. The 360 system would continue to be used for all batch work, large compute-bound jobs, special languages, etc.

The HP 2000C system was available for the 1971–72 academic year. The questionnaire results showed a high level of voluntary use of the machine by students, in addition to their assigned course work, especially for second-year MBA and for Ph.D. candidates. This heavy use indicates that Stage 4 in the model has been attained; the system is being used as a general problem-solving tool.

Research use of the HP 2000C and 360/67 batch system is high—more than half of the faculty have accounts on one or both machines. Each instructional area in the school has at least one faculty member who is a computer user. It is thought that the expanding use of the computer resources by the faculty is a result of two factors: greater computing capacity, which stimulates more demand; and the changing composition of the faculty, which includes more computer users than in prior years. (The most highly rated reason for the faculty's using the HP 2000C was its availability without charge.)

Part of the study was devoted to assessing the impact of the dedicated time-sharing system on the school and the users. After the installation of the HP 2000C, the instructional component of the budget on the 360/67 dropped dramatically; the major impact came from the transfer of the required computing course to the dedicated time-sharing system during the first quarter. The new system did little to decrease the demand for

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Authors' address: Graduate School of Business, Stanford University, Stanford, CA 94305.

SCC services on the 360 during the last two quarters of the year. As resources were freed on the campus facility, new classroom uses developed for which only the 360 was suitable; in the past, funding these requests would have been more difficult. While student usage dropped $40,000, the total budget on the 360/67 declined by only $16,000 after the HP 2000C was installed. This small decline was due to new instructional uses for the SCC machine, and the fact that unsponsored faculty and Ph.D. research nearly doubled during 1971–72.

The questionnaire results showed that second-year MBA students who used both systems had more favorable ratings of the dedicated HP 2000C for ease of use, availability, and reliability. The 360/67 was rated more highly on quality of error feedback and response time. The response time rating may become a significant problem as demand increases; a faster processor has been ordered, and coordination in the scheduling of assignments will be used to balance the workload.

The data in general show that students in different programs have different usage patterns. It is clear that as more computing resources are provided there will be a demand for even more capabilities. Faculty and students place many different requirements on a school's computing resources. Because of these different demands for computing at an advanced stage of computing use, the model and data from this study support the philosophy of providing a variety of computer resources ranging from a dedicated time-sharing system to a sophisticated batch processing machine in a business school environment.

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INTEGRATING THE COMPUTER INTO A BUSINESS SCHOOL CURRICULUM*

Henry C. Lucas, Jr., *Stanford University*
Jean Claude Larreche, *Stanford University*
David B. Montgomery, *Stanford University*

ABSTRACT

The results of a study of computer utilization in the Graduate School of Business at Stanford are presented. The benefits and costs of a dedicated time-sharing system acquired by the Business School to supplement the central campus computer facility are discussed. The study showed that the time-sharing system produced many benefits, including improved service and a lower per student cost for computing. The implications of the Stanford experience for other schools are discussed.

INTRODUCTION

Background

In the past six years, U.S. business schools have drastically expanded their use of computers in teaching and research. In one 1966 survey, only 11% of the schools responding required student proficiency in programming: by 1970 that number had increased to 62% and is undoubtedly even higher today [4]. The purpose of this paper is to describe the results of a study of the use and impact of computers within the Graduate School of Business (GSB) at Stanford University in order to provide other schools with insights into their own expanding computer use. The paper discusses the overall effect of computers on the School and focuses on the particular impact of a dedicated time-sharing system acquired by GSB to augment its computing resources.

Summary of Findings

Before presenting the details of the study of computing resources at GSB, an overview of the findings is summarized below.

1. The Stanford experience follows a cumulative process model of computer development.
2. The acquisition of a dedicated time-sharing system which is treated as a free good for an initial investment of under $250,000 has had a major impact on the environment of the school. (This system supplements use of a central campus IBM 360/67 facility which offers both time-sharing and batch services.)

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a. The total cost per student for instructional computing was reduced from $155 per MBA student to $145 the year after the acquisition of the time-sharing system. The $145 per student figure is significantly lower than a conservative projection of a cost of $210 to provide improved services on the 360/67 alone. (The operating costs of the new time-sharing system accounted for $108 per student while continued instructional use of the 360/67 cost $37 per student.)

b. The expenditures for unsponsored faculty research increased from $327 to $636 per faculty member the year after the acquisition of the new time-sharing system. New research uses appeared for the central campus system instructional funds freed by the use of the time-sharing system.

c. The intangible benefits of the time-sharing system included more ease of use, greater availability and greater reliability when compared with the 360/67 by the students. The time-sharing services of the 360 were rated higher than the new time-sharing system on the quality of error feedback and response time.

d. The availability of terminals and the lack of charges for computer time were the major advantages of the time-sharing system cited by the faculty.

3. Computer demands can be expected to increase as new computing resources are provided. Attempts to reduce computer expenditures by changing the mix of equipment available have to be carefully planned to avoid raising user expectations and stimulating additional demands for computer resources.

HISTORICAL BACKGROUND

Graduate School of Business

There are 300 MBA students in each of two classes, about 75 Ph.D. candidates in residence and about 70 faculty members at the Stanford Graduate School of Business. Prior to the spring of 1971, all computing at GSB used the facilities of the Stanford Computer Center. The Center has an IBM 360/67 and offers interactive Basic, Fortran, a text editor (Wylbur) and a variety of batch and remote batch services.

By the Fall of 1970, the Business School was confronted with several serious computer problems created by heavy computer use, increasing demands for services, and the availability of only 15 terminals. To use interactive BASIC it was necessary to teach a sophisticated text editor. The use of the machine was also constrained by budget considerations; a connect fee based on terminal usage and a CPU charge was made. The bulk of the teaching budget was absorbed by charges for terminal connect time for students. There had also been some problems with the reliability of the 360/67. The interactive and batch system on the 360/67 is very complex and experiences occasional downtime. The small number of terminals, and the nature of computing for instructional use necessitated an extremely reliable system for GSB.

A decision was made in the Fall of 1970 to acquire a Hewlett-Packard (HP 2000C) dedicated time-sharing system for use in the Graduate School of Business.

More details on that decision and an evaluation of the performance of the system can be found in [9]. The system was installed in the Spring of 1971 and was used during the 1971-72 academic year. In addition to increasing the number of terminals available, provision was made to extend the hours of the terminal room. The system is treated basically as a free good; there are no charges for instructional or research computer time, though disk storage space is rationed.

Research Methods

In the Spring of 1972 there was a unique opportunity to evaluate the computing resources of the Graduate School of Business and examine the impact of the time-sharing system. Most second-year (graduating) students had used the 360/67 during the first year of the MBA program in the required computer course and in other courses. A number of these same students then used the 2000C time-sharing system during their second year of the MBA program, 1971-72. All of the new first year students in 1971-72 had been exposed to the 2000C time-sharing system; a few had used the 360/67 in addition. During this period, the faculty had used both systems and had been converting a number of teaching and research projects to the 2000C time-sharing system.

Accounting records were examined in detail for both the 360 and the 2000C to obtain the overall pattern of use. A questionnaire survey was also conducted of first year students in a required marketing course, of second year students through selected classes, and Ph.D. and faculty through interdepartmental mail (see [10]). Interviews were held with a number of faculty members. The sample consisted of 195 first year students, 89 second year students, 42 Ph.D. students and the 22 faculty members who had accounts on the HP 2000C.

A PROCESS MODEL OF COMPUTER USE

The results of an earlier study [4] suggest a cumulative process model of the development of computing in a business school. In the first stage, the computer is used by a few faculty members and Ph.D. students for research. Pressure from the external environment, changing faculty composition and interests, and student interest combines with the impetus provided by research to lead to a demand for a required computer course in the curriculum. This required course marks the beginning of Stage II which builds upon and includes the Stage I processes.

The exposure of students to a required computer course then facilitates the utilization of computerized cases, exercises and projects in other areas of the curriculum (Stage III). This widespread use of the machine builds student reliance on the computer in general and leads to Stage IV, the final one, in which the machine is treated as a general problem solving tool. During all of these stages different responses and patterns of use develop for subgroups among the students and faculty depending on their particular needs.

Stages I and II: Research and Required Course Use

The historical development of computer use in the Business School can be seen in Table 1.[1] Until 1968-69 the computer was used primarily for research purposes corresponding to Stage I in the model. Stage II began in the fall of 1968 when a required course, Management and the Computer, was introduced into the first-year MBA curriculum. By the end of their first quarter, students knew how to use the computer equipment, and the faculty could assign computer exercises without having to be concerned about the ability of students to use the machine.

TABLE 1

360/67 Budgets in $1000[a]

	1967 –68	1968 –69	1969 –70	1970 –71	1971 –72
Faculty Course Development	NA	NA	16.6	4.1[b]	4.4[b]
%			(12)	(4)	(5)
Student Use	NA	NA	72.4	68.1	17.5
%			(54)	(64)	(19)
Ph.D. Dissertation	NA	NA	20.5	12.0	24.7
%			(15)	(11)	(27)
Instruction Subtotal	12.2	95.7	109.5	84.2	46.6
%	(32)	(79)	(82)	(79)	(51)
Unsponsored Faculty Research	25.6	25.7	23.9	22.9	44.5
%	(68)	(21)	(18)	(21)	(49)
Total	37.8	121.4	133.4	107.1	91.1
%	(100)	(100)	(100)	(100)	(100)

[a] Exclusive of terminal rental and sponsored research

[b] A course development NSF grant contributed substantial additional amounts in 1970-71 and 1971-72 to course development.

NA = not available

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[1] The data in this report in general include only unsponsored computer funds; grant information is confidential and charges for sponsored computer use are not aggregated in any one account. (Some of these data were examined: see note 2.) Thus, the total GSB expenditure for computers is higher than shown. Also, there are a few users of external time-sharing systems because of languages or special data bases.

Stages III and IV: Extension to Other Courses and Problem Solving Use

The use of computers for instructional purposes spread rapidly to other courses after the introduction of the required computer course. Use of the 360/67 increased in the 1969-70 year (see Table 1), reflecting the increased number of courses involving computer work. The large expenditure for course development in 1969-70 helped expand computer use for instructional purposes as new exercises were developed. A curriculum development grant from NSF provided a strong stimulus to this process. (A general budget reduction in the 1970-71 year necessitated a decline in computer use.) Both these data and the results described below indicate that GSB had reached Stage III in the model by the 1969-70 academic year.

In the spring of 1970-71 the HP 2000C system was introduced. An analysis was made of the pattern of use for both the 1970-71 and 1971-72 years for the 360/67, and the 2000C during its initial year, 1971-72. These data indicate that Stage III in the model has been reached; the use of the computer is not restricted to one course or even one year in the program. There is heavy use of computing for the required introductory computer course in the Fall and for other first year courses. Heavy use was observed for second year MBA students during the same period. Aside from these accounting data, students were also asked on the questionnaire to list courses in which they had used the 2000C; over 50 different courses out of a total of about 75 courses were mentioned [3]. A large number of computer exercises in different areas have been developed for the 2000C or transferred from the 360/67. These results clearly indicate the pervasive nature of computing at the Stanford Business School; required and elective courses in both years of the MBA program make extensive use of computer facilities.

The questionnaires also show that voluntary use of the system increases significantly from first-year MBA to second-year MBA students to Ph.D. candidates. See Table 2. The questionnaire results indicate a pattern of required cases and exercises during the first year of the MBA program. During the second year, more voluntary use is made of the system through utility programs or the students writing their own programs. The system is more of a problem solving tool for second-year MBA and Ph.D. students. These results would be expected in a school which has reached Stage IV in the model; high voluntary use suggests that the computer is regarded as a general problem-solving resource.

BENEFITS OF COMPUTER USE

The benefits of computer use in a business school are difficult to quantify. Most of these benefits must be treated as intangible due to the absence of indicators of the benefits of the educational process itself. Intangible benefits are indicated by usage patterns, the impact of computers on the curriculum, and user attitudes toward computer resources in the discussion below.

TABLE 2

2000C Student Usage Pattern

	MBA 1[1]	MBA 2	Ph.D.	F[2]
General Use				
Use ⩾ 1/week	69%	33%	52%	NA
Voluntary Use	16.5% (194)	32.2% (79)	65.2% (40)	52.0†
Proportion of Time Spent on:				
Utility program	38.7% (185)	49.5% (77)	37.3% (30)	4.51*
Case solutions	33.3% (185)	20.8% (77)	13.3% (30)	12.6†
Writing program	27.7% (185)	29.8% (77)	49.3% (30)	7.63†

[1]Percent (Number)

[2]Analysis of Variance

*$p < .01$

†$p < .001$

NA = not applicable

USAGE PATTERNS

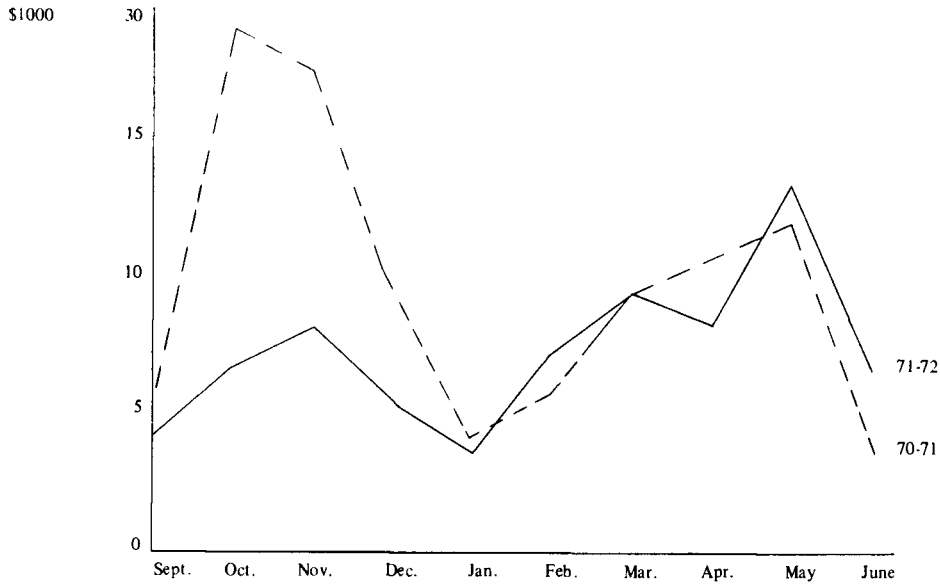
Student Use

The 2000C was acquired to handle the major demand for computing for instructional purposes; use of the system where possible for research has also been encouraged. Table 2 shows that a minimum of one-third of the students in the school report using the HP 2000C more than once per week. The impact of the 2000C can also be seen by reviewing the data in Table 1. The student use component of the 360/67 budget decreased significantly after the installation of the 2000C system in 1971. The exact nature of the shift of classroom use is illustrated more clearly in Figure 1(a). The major impact on the 360/67 budget occurred in the fall quarter as the introductory computer course load was transferred to the 2000C. In fact, the similarity of the 1970-71 curve for the 360/67 expenditures and the graph for time used on the 2000C during 1971-72 (Figure 1(b)) confirm that much of the instructional computing load was transferred to the 2000C.

It is interesting to note that the 1971-72 budget on the 360/67 for Winter and Spring quarters is quite similar to the corresponding period during the prior year when the 2000C was not available. In fact, the May 360/67 expenditures in 1972 exceeded the May 1971 charges. The new system did little to decrease demand for 360/67 services during the last two quarters of the year. The number of elective, second year

FIGURE 1

(a) Total 360/67 Expenditures



(b) Total 2000C Time 71-72

courses using the 360/67 stayed about the same in 1971-72 as in 1970-71; however, the mix of courses changed. As 360/67 resources were freed by the availability of the 2000C, new classroom uses developed for which only the 360/67 was suitable. In the past, providing 360/67 time for these courses would have been more difficult.

Faculty and Research Use

Computer resources have been used heavily in research throughout the period studied (see Table 1[2]); faculty research on the 360/67 has increased steadily. The widespread use of computing in research (and to some extent teaching) is evidenced by the fact that thirty-four faculty members had personal accounts on one of the computer systems; twelve faculty members had accounts on the 360/67 only in 1972, ten had accounts on the 2000C only, and twelve had accounts on both machines. Each instructional area in the school has at least one faculty member who is a computer user.

The heavy faculty usage of computers and the increasing trend for faculty research using computers may be due to two factors. First, an expanding computer capacity may stimulate requests for additional resources and encourage projects because more total resources are available. Another possibility is that a change in the composition of the faculty has created an increased demand for computing. (The size of the faculty remained relatively stable during the 1970-72 period.) About 39% of the 1967-68 full-time faculty could be classified as computer users;[3] in 1971-72 this percentage had increased to 65%. Of the 29 new permanent faculty members added between 1968 and 1971, 23 (about 80%) are computer users. In the absence of more data, the underlying cause of the results cannot be determined; however, the widespread use of computers and increasing research demands for computing are probably due to a combination of the availability of computing resources and the changing composition of the faculty.

The most frequently mentioned reasons for using the 2000C by the faculty are the absence of charges and the availability of terminals. The 360 is used primarily because of its efficiency and available packages. Interviews with faculty members provided additional information on the impact of the 2000C on their research and teaching activities.

For several faculty members, research was initiated on projects which would not have been attempted if charges were made for computer time. An example of this type

[2]A sample of research grants in which it was known that the computer had been used were examined. The purpose of this analysis was to determine if changes in the amount of sponsored research distorted the trends in unsponsored research. The results indicate that most of the computer use under sponsored research would not have occurred without the grant and that any impact on the observed trends for unsponsored research was minimal with the exception of the NSF Curriculum Development Grant mentioned in the text and in Table 1.

[3]Full-time here is defined to be faculty members appointed for at least a three-year term. Some of these individuals might not have personal accounts because of collaborative research with another faculty member or the use of research assistants for computer work. The classification "computer use" is based on whether their research requires the use of computers.

of project is an extensive Monte Carlo simulation which involved over 50,000 regressions on simulated data. The objective was to assess the finite sampling properties of certain econometric procedures under a wide variety of conditions. This project would have exhausted a substantial fraction of the total research funds available for the 360/67. The 2000C was used essentially as an overnight batch processor at no charge.

Some faculty members developed assignments or course projects for the 2000C which would have been too expensive or difficult to administer on the 360/67. It is also clear from the data that the presence of a free computing resource has stimulated more assignments using the computer. As mentioned earlier, some of the freed student funds from the 360/67 budget were allocated for additional research and for using the 360/67 in courses where funding would have been difficult in earlier years.

The Impact of Computing on the Curriculum

As discussed above, the MBA curriculum uses computer resources heavily. A sample of some of the instructional uses of computers is presented in Table 3. These examples provide some of the flavor of the many course assignments and demonstrations which make use of computers for problem solving. After the completion of a required computer course during the first quarter, it is assumed that students can use a computer routinely to solve class problems in other required and elective courses.

Heavy computer usage continues during the second year where computers are frequently used for special projects as well as regular assignments. For example, in one class a data base of financial information is available and students prepare programs to analyze the data and test their own hypotheses as a term project.

The system is also used heavily by Ph.D. students, many of whom contribute programs to the public library. One group of Ph.D. students taking a research methods and statistics course developed a series of nonparametric routines which are now available on the system. One of these students was given financial support to develop a data management system for statistical packages [2] [3]. A single equation econometric system which uses this data management package was recently added to the computer library by another group of students and faculty [6]. In this manner a library of programs is gradually being constructed for further classroom and research use.

Even though not directly related to the academic curriculum, the dedicated time-sharing system has also had an impact on the administration. Staff members in the accounting and financial areas of the school have learned to write programs and use the system for analysis. A major system has been developed to assist the registrar of the Business School by maintaining records of classes, students and grades.

User Attitudes

A number of reasons for acquiring the 2000C system were described earlier. Part of the questionnaire was devoted to assessing user reactions to the new system in order to determine its adequacy. It was predicted that all user groups would have more favorable ratings of the 2000C on ease of use, the quality of error feedback, response

TABLE 3

A Sample of the Instructional Use of Computer Resources by Functional Area

First Year of MBA Program

Computer and Information Systems. The HP 2000C system is heavily used by all first-year students when learning the BASIC programming language in the introductory computer course.

Decision Sciences. In these courses, students use statistical and mathematical programming packages such as multiple regression, analysis of variance, non-parametric statistics, linear and integer programming. Programs have also been developed for specific cases to illustrate the use of Monte Carlo simulation and decision tree analysis.

Economics. A macro-economic game, available in six versions of increasing complexity is used by the students to test their understanding of fiscal and monetary policies.

Finance. Students use programs to evaluate stocks.

Management of Operating Systems. Programs corresponding to specific cases are used to illustrate the use of heuristic methods in facility layout planning and the consideration of learning curves in production.

Marketing. Two or three cases are used to introduce the students to interactive market planning in the contexts of advertising, budgeting, of establishing the marketing mix, and of assessing the risk characteristics of price strategy for a new industrial product.

Second Year of MBA Program

Computer and Information Systems. The largest usage of the HP 2000C in this area is in the Simulation course, where students use existing models and also develop their own. The 360/67 system is also heavily used as it is the only one to provide simulation languages such as GPSS or SIMSCRIPT.

Decision Sciences. Students use mathematical programming routines on the HP 2000C. Two large models are also available in Fortran on the 360/67.

Economics. Students use the HP 2000C to run regression packages.

Finance. This area makes use of a large number of programs such as the Stanford Portfolio Management Game, the Stanford Commodities Futures Game, investment strategies analysis programs, portfolio evaluation routines and regression packages.

Marketing. Computerized case analyses are used rather extensively in three courses: Marketing Models, Market Research and Market Communications. The cases deal with competitive bidding, micro simulation of a market, advertising budgeting, decision analysis of a new product introduction, regression analysis for historical and experimental market measurement, and market forecasting based upon early sales results for a new product.

Policy. Two computerized cases are used in policy. The first deals with the financial analysis of a proposed acquisition. The second entails an input/output model for assessing the primary and derived consequences of alternative strategies in county development.

Ph.D. Program

Ph.D. students use many of the programs described above. In addition, they use other programs designed primarily for Ph.D. courses, such as an Auto-regressive Model Simulator and a Correlated Normal Random Variate Generator designed for the Ph.D. econometrics course.

Executive Courses

Executive courses such as the one-year SLOAN course and the Senior Executive Program make use of the same programs as the MBA courses. In addition special programs have been written to teach computer fundamentals to these executives.

time, availability and reliability. These predicted differences were expected to be particularly strong when the 360/67 was compared with the 2000C by students and faculty having experience with both systems. These students, primarily in the second year of the MBA program, had used the 360/67 for the introductory computer course and experienced a number of frustrations with downtime and with the complexity of the text editor and the batch operating system. During their second year, the students did most of their computing on the 2000C. It was also predicted that higher frequencies of use would be associated with favorable ratings.

The predictions for ease of use, availability and reliability are supported by the results in Table 4. However, contrary to the predictions, the 360/67 was rated more highly on quality of error feedback and response time. The error response rating may have occurred because some students do not realize that they have to follow a simple procedure to obtain diagnostics from the 2000C which are provided whether wanted or not by the 360/67. If this is a correct assessment, this feature of the 2000C should be emphasized in training and in system documentation. The finding on response time is potentially more serious. In an academic environment, workload peaking is a constant problem due to assignments given to large classes and the tendency to have work in all classes due near the end of a quarter or semester.

Several questions asked the respondent to rate how his use of the 2000C system contributed to the development of four managerial skills including the ability to analyze problems, make decisions, do research and apply techniques. The small, but significant, correlations between the frequency of use and contribution to management skills in Table 5 support the prediction that greater frequency of use is associated with a more favorable evaluation of the system.

COSTS OF COMPUTER USE

Table 1 shows the costs of using the central IBM 360/67 system for classroom and research use before and after the acquisition of the HP 2000C system by the Business School. The HP system was acquired for a total investment of under $250,000 including site preparation, but excluding terminal rental. The operating expenses (in thousands) for the GSB computer operation during the 1971-72 year included:

Terminal lease	$30.6
Salaries (excluding faculty supervisor allocation)	17.5
Maintenance on HP and CRT terminals	11.1
Miscellaneous, supplies, etc.	5.6
Total operating expenses	$64.8

The above figures can be combined with the data from Table 1 on 360/67 expenditures to obtain a rough idea of the per student computer costs before and after the acquisition of the dedicated time-sharing system. (All students in the school are

TABLE 4

2000C and 360/67 Ratings

Attribute		Group: MBA 2	Group: Faculty
Ease of Use	2000C[1]	5.6 (70)	6.4 (15)
	360/67[1]	5.1 (75)	4.2 (11)
	t[2]	2.6 (67)†	5.0 (10)†
Feedback quality	2000C	4.3 (65)	4.0 (14)
	360/67	4.9 (71)	4.9 (11)
	t	−2.3 (62)*	NS
Response time	2000C	4.1 (70)	4.3 (15)
	360/67	5.4 (74)	4.5 (11)
	t	−4.5 (67)†	NS
Availability	2000C	6.0 (72)	6.0 (15)
	360/67	3.6 (75)	4.0 (11)
	t	9.9 (68)†	4.5 (10)†
Reliability	2000C	5.6 (66)	6.0 (14)
	360/67	3.7 (71)	4.1 (11)
	t	7.9 (63)†	3.6 (9)†

[1]Mean (number)

[2]t value (number)
+ t means 2000C more favorable than 67
− t means 67 more favorable than 2000C

*$p < .02$ (two tailed)

†$p < .01$ (two tailed)

NS = not significant

registered for a full load of courses; there are no part-time students.) In the analysis below, it is assumed that instructional computing is the major reason for MBA usage so that 600 students are involved in this category of use. (The few Ph.D. students taking courses have a small impact on instructional use.) For research purposes, the total number of researchers includes the entire faculty and all Ph.D. students. While the major use of the HP 2000C is for teaching, there is some research use as described earlier.[4]

[4]Unfortunately, there is no way to determine how much of the use of the HP system is for research so all of the HP expenditures are allocated to instructional use. Research expenditures represent the "Unsponsored Research" category from the 360/67 budgets in Table 3.

TABLE 5

Contribution of 2000C to Management Skills

Correlation of Frequency of Use with Ability to	MBA 1[1,2]	MBA 2	Ph.D.	F[3]
Analyze problems	4.5 (193)	4.4 (76)	3.7 (34)	3.1*
Make decisions	4.4 (193)	3.8 (75)	3.0 (33)	11.8††
Do research	3.9 (179)	4.9 (73)	4.9 (34)	9.5†
Apply techniques	5.2	4.9	5.1	NS

[1] Mean (number of respondents)

[2] A seven point scale was used; higher numbers are more favorable.

[3] Analysis of variance

*$p < .05$

†$p < .01$

††$p < .001$

NS = not significant

In 1970-71, the per MBA student instructional expenditure on the IBM 360/67 was $155.[5] In 1971-72, the per MBA student cost of the HP 2000C system was $108. However, continued instructional use of the 360/67 ran $37 per student giving a total instructional cost per student of $145. From 1970-71 to 1971-72, Ph.D. dissertation expenditures on the 360/67 increased from $160 per student to $329 and unsponsored faculty research expenditures rose from $327 to $636 per faculty member.

These data confirm the fact that the time-sharing system did not completely remove the need for classroom use of the 360/67. The cost of the HP 2000C system per student was less than the 360/67 expenditures in 1970-71. Even the total costs of computer per student including continued classroom work on the central facility were less after the acquisition of the time-sharing system ($155 per student compared with $145 per student). These figures also demonstrate the increased demand for 360/67 research computer time that Ph.D. students and faculty perceived to be freed by the acquisition of the dedicated time-sharing system.

In addition to decreasing per student computing costs, the acquisition of the dedicated time-sharing system also improved service. How much might it have cost in

[5] The budget for the 360/67 in Table 3 excludes terminal costs. For the purposes of this analysis, the costs of the terminals replaced by the HP ($25,000 per year) has been added to the instructional charges for the 360. The cost of terminals is dropping and possibly lower cost terminals to the 360 could be acquired. However, that possibility was not included in the analysis.

1971-72 to provide a comparable improvement in service using only the 360/67? A conservative estimate that instructional usage would increase by 50% and that no additional terminals would be acquired results in a projected 1971-72 cost of $210 per student using only the 360/67. However, this figure is probably too conservative; the faculty and administration agreed that more terminals were needed. Providing the same number of terminals as are available with the HP 2000C and assuming the same 50% increase in instructional charges, results in a projected cost of $253 per student using the 360/67 alone. Finally, assuming the increased number of terminals and a doubling of instructional computer charges, provides an upper bound on the projected 360/67 per student cost of $310. The $145 per student actual cost for the combined HP 2000C and 360/67 resources in 1971-72 is considerably below even the most conservative estimates for providing improved service on the 360 instead of acquiring the time-sharing system!

CONCLUSIONS

The cumulative process model of the development of computing use in a business school has been supported by the data from this study. It is important to note that the evolution of computer use may be limited if adequate resources are not provided to meet demand and encourage use. The GSB might never have achieved Stage IV limited to the university 360/67 system and its budget constraints.

The history discussed here for a business school is one possible scenario for how computer demands develop and expand. Other business schools have attained different stages in the model through the use of a variety of computing resources. Some schools use a university computer center exclusively while others rely heavily on outside computer services provided by commercial time-sharing firms. A few schools have developed an internal capability on a dedicated computer. Different conditions may also move an institution to different stages in the model. For example, special faculty training programs, the addition of an enthusiastic computer area leader, or administrative efforts to integrate computer exercises into the curriculum can stimulate greater use of computers. The recent availability of computerized case materials should also stimulate computer demands [1] [5] [7] [8].

Expanded computer usage is undoubtedly a joint function of student demand and faculty interest; mechanisms which encourage both will accelerate computer development in a school. For example, the elimination of charging should increase demands by both faculty and students. The availability of an easy to use system such as BASIC and a simple command language on a system encourage use by making it easier to learn the system and less frustrating to solve problems with the computer.

One of the major impacts of the time-sharing system at GSB was the change in computing costs per student for instructional computing. The total cost per student decreased after the acquisition of the HP 2000C. New classroom uses for the central IBM 360/67 appeared and research use of this system increased dramatically. This experience suggests that the acquisition of a dedicated system may not be successful in reducing total computing expenditures. Demands which could not be fulfilled earlier arise to consume freed resources. A school planning to reduce computer expenditures

by moving to a dedicated time-sharing system from a central computer facility must plan carefully to avoid raising expectations and demands which can not be met.

The benefits of any set of computer resources are difficult to measure. In this instance, the change in machines provided an opportunity to examine student and faculty reactions and compare the two computer systems. The new time-sharing system was rated more highly on ease of use, availability and reliability than the 360/67. However, the central campus machine had higher ratings on the quality of error feedback and response time. The major advantages of the time-sharing system from the viewpoint of the faculty was the greater availability of terminals and the lack of charges for computer time.

Because it is impossible to quantify the benefits from the expanded mix of computer resources, a benefit/cost ratio cannot be calculated. However, the fact that service was increased while costs were lowered suggests that the majority of the GSB faculty, staff and students would regard the acquisition of the dedicated time-sharing system as a worthwhile investment.

It should be clear from this study that there is a wide diversity of computer use and needs among professional degree candidates, Ph.D. candidates and the faculty of a business school. Analyzing these needs and providing the variety of computing resources necessary to fulfill them is a major challenge for management schools.

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